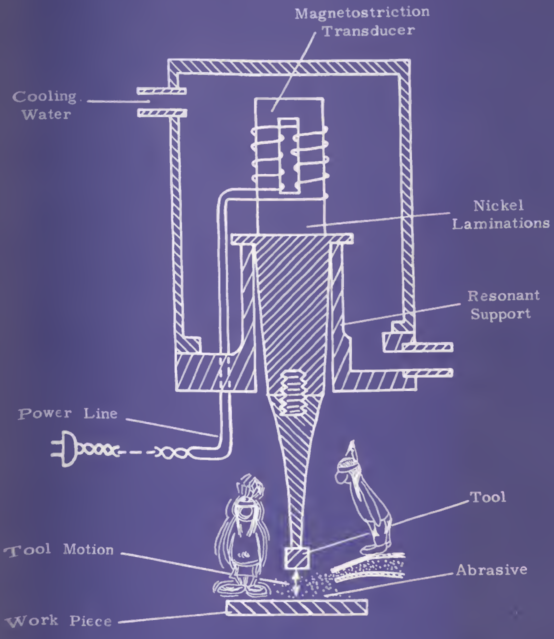
Mechelecciv

Volume 23 October - 1964 No. 1



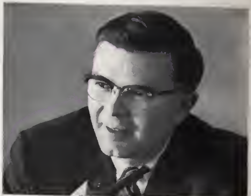
ULTRASONIC IMPACT GRINDER

THE GEORGE WASHINGTON UNIVERSITY

OCTOBER 1964

STEP FORWARD WITH FORD MOTOR COMPANY

An Open Letter to the 1965 College Graduate from Donald N. Frey, Assistant General Manager, Ford Division of Ford Motor Company



Donald N. Frey was awarded a bachelor's degree in metallurgical engineering by the University of Michigan in 1947 and a doctorate in 1950. One year later, he joined Ford Motor Company as manager of the Metallurgical Department in the Scientific Laboratory. In 1962, Dr. Frey was appointed assistant general manager of the Ford Division with responsibility for all engineering, product planning and purchasing activities. He is 41 years old.

America's automobile industry is in the midst of a challenging era, with prospects of an even more exciting and demanding tempo in the years to come. Ford Motor Company is determined to achieve leadership in all phases of its operation. This leadership promises to bring lasting success to the company, its employes and its stockholders.

It will take people to accomplish this objective. Engineering, finance, styling, marketing, product planning, sales—all require people with the knowledge, judgment and personal drive to avail themselves of the unprecedented opportunities offered by a great industry.

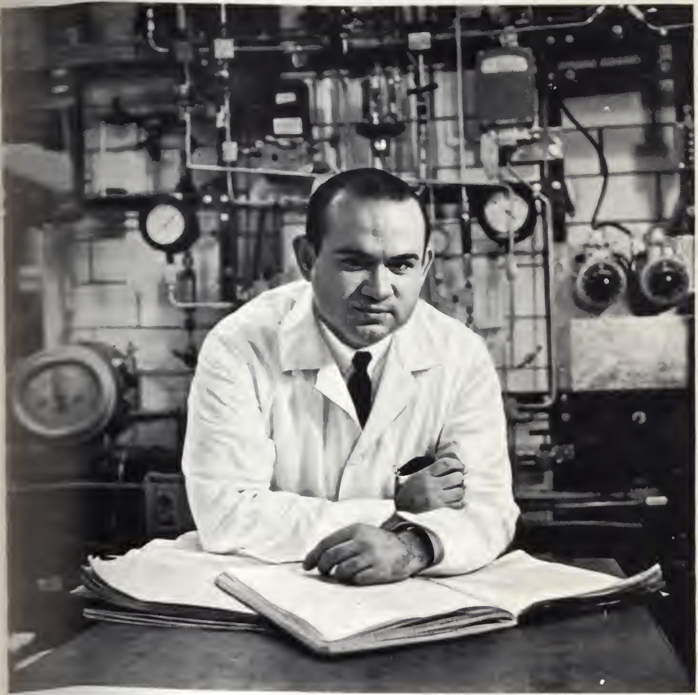
The automobile business is growing. More cars are being bought now than ever before. With increases in population and consumer buying power, even more will be bought in the future. Realizing this, Ford Motor Company seeks to attract college graduates who have the capacity to grow with the company and the market.

Right now, our plans call for employing about a thousand of the best 1965 graduates we can find, with all types of educational backgrounds. We need specialists, but we also need persons with broad liberal-arts training who can handle a wide variety of assignments. Actually, in our company, many graduates grow into jobs totally unrelated to their degrees. They have discovered that Ford offers intellectually challenging opportunities for those with the ability to seize them. We invite you to make the same discovery.

Contact your Placement Office and arrange to see our representative.

Ford
MOTOR COMPANY
The American Road, Dearborn, Michigan

An Equal Opportunity Employer



IN MEMORIAM

Thomas H. Carroll

1914 -- 1964

Before we become too engrossed in our engineering studies, it is well to reflect on the life of our University's honored President which ended so suddenly on July 27 of this year. In the death of Thomas H. Carroll, our University has lost a resourceful, energetic leader.

Under his direction, The George Washington University began a vigorous program of academic growth. Total enrollment grew from 9,595 to 11,246 or 17 per cent, and full-time enrollment increased from 3,659 to 4,437 or 21 per cent. During his three and one-half years as President, he increased dormitory space by 320 per cent. Funds for sponsored research increased by 49 per cent. The Institute of Sino-Soviet Studies was added to the School of Government, Business, and International Affairs. President Carroll was instrumental in the formation of the consortum plan in which any graduate student at George Washington, Georgetown, Catholic, Howard, or American University can get credit for courses taken at any of the other Universities. He brought about a 50 per cent increase in the budget for faculty salaries and a 39 per cent increase in the overall annual operating budget of the University. And . . . The accomplishments of an active, hard-working man never seem to end. They have, however.

Thomas Henry Carroll's energy and enthusiasm, his notable achievements, his pursuit of academic excellence, and his full service to his fellow man should stimulate each of us, as best we can, to match his example in our own lives. As President Lyndon B. Johnson said following the death of another eminent noble man. . . "Let us Continue."

J.L.E.

the Mecheleciv

VOLUME 23 OCTOBER - 1964 No. 1

ARTICLES page

DEPARTMENTS

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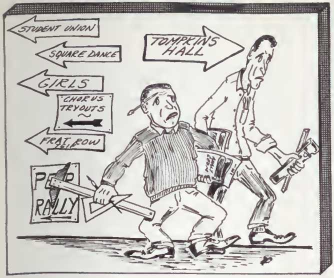

POINTERS

for the

Introductory Level

Student

THE IMPORTANCE OF SCHOLARSHIP

Scholastic achievement never goes unnoticed (and we don't mean by professors). The Engineering honorary organizations realize the importance of fine scholarship and recognize worthy students for membership. Honest effort, character and grades are the bases of their selections.

But the true worth of scholarship extends far beyond this point. You are depending on your college experience to recommend you to a future employer. Therefore, a faulty performance may hurt you later professionally.

If you are having trouble, see your advisor immediately! Don't hesitate until it is too late. He will be happy to help you himself or recommend you to a tutor. Many students have benefitted from such help.

STUDY HINTS

1. Study regularly, beginning now.
2. Plan your work to avoid hopeless pileups and all-night cramming sessions.
3. Review throughout the semester.
4. Eliminate unnecessary distractions when you study: radio accompaniment, intermittent conversation, clutter of distracting objects. Why handicap yourself?
5. Work when you work. Short sessions of intense study are more profitable than all-evening sessions of wool gathering.
6. Read with a purpose. Look for main ideas. Test yourself with recitations as you go along. Use notes or underlining to help you grasp the framework.
7. Think during lectures. Taking notes helps. Remember that, as in reading, there are only a few ideas being presented at a time.
8. Overlearn what is important. Practice explaining it.
9. Get help when you need it. Professors expect to give individual help as well as teach classes.
10. Sharpen your tools. A slow reader can speed up with practice. Join a special reading class. Your professor can help you analyze your weaknesses in background and help correct them.
11. You have to want to learn. Interest can grow if you honestly try to see the usefulness of the things you study and their interrelationships. Greater interest comes with success.
12. Study to gain ideas and skills and you will be on the best way toward getting the desired grades.
13. Two hours of preparation on the part of the student are normally required for each hour of lecture or recitation.
14. Get to know members of the faculty.

WORK HABITS

In order to have some free time for relaxation or extracurricular activities, you need to form good work habits for college work. You're on your own. Between classes you may do whatever you please, but in class you'll be expected to know the answers.

EXTRACURRICULAR ACTIVITIES

The many benefits to be derived from participation in extracurricular activities are indicated by the interest of placement officers from industry in such activities. Good scholarship, the ability to work harmoniously with others, and a well-rounded personality are qualities sought in prospective employees and participation in student activities has its place in developing some of these traits.

All students face the problem of deciding how extensive their participation in extracurricular activities should be. Every student, whether full or part time, should have some part in the college life which surrounds him. He should do more than just attend classes and study. On the other hand, it must never be forgotten that studies come first.

The experience of the students who have preceded you indicates that the first semester of the freshman year should be one of acclimation to new surroundings and conditions and observation of the many extracurricular activities available. A sensible program of participation in extracurricular activities for a first semester might include membership in one of the Professional societies, which would take up one or two evenings per month, and possibly membership in one other activity which would not require more than eight or ten hours per month.

ULTRASONICS in

The "Encyclopedia of Electronics" defines Jltrasonics as:

"Ultrasonics is the generation and detection of ultrasonic vibrations in materials having elastic properties. The frequency range is above the top limit of the audible range and extends from approximately 18 K.C. to above 200 M.C."

The particular frequency range can not be expressed explicitly. Actually, "above the audible range" will vary from 14-20 K.C. for different individuals, and as for the upper limit there isn't any theoretically speaking. If a longitudinal wave front creating a deflection in a material can be produced and detected, then these are ultrasonic waves. But the frequencies used in most applications of ultrasonics are usually in the 18-50 K.C. range.

Some of the industrial applications of ultrasonics are:

1. Basic Metal Production -- quality control testing for defects in ingots, blooms, billets, and plate.
2. Ingots and Castings -- agitating molten metal during casting to improve grain structure.
3. Testing for defects and homogeneity in forgings; extrusions; weldments, brazed and cemented joints, and sintered metals.
4. Measuring thickness from only one side.
5. Faster and more effective cleaning of parts.
6. Electroplating -- higher current density with improved quality.
7. Heat Treating -- improvement of grain dispersion.
8. Drilling and Impact Grinding -- especially of the harder materials such as carbids.
9. Welding -- cold joining of foils and thin sheets.
10. Welding, Brazing, and Soldering -- assists in hot joining with improved structure and without use of fluxes by dispersing any oxidation formed.
11. Measurement of the physical properties of metals and other materials.
12. Determining deterioration by measurement of ultrasonic velocity changes.
13. Location and measurement of cracks in dams and other large structures.
14. Homogenizing milk.
15. Speeding up chemical reactions.
16. Mixing of solids and gases and liquids.
17. Echo sounding -- Sonar.

From the foregoing list of applications, one can see that ultrasonics is a well established industry in itself. There are presently approximately 75 companies in this country which manufacture and sell various types of ultrasonics equipment.

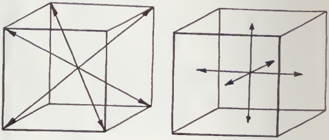

FIGURE 1
Directions of easy magnetization for nickel and iron.

TRANSDUCERS

From the definition of ultrasonics "Generation and Detection" comes the term "transducer," an instrument for converting any form of energy into sonic or ultrasonic waves and visa-versa. The nature of transducers varies according to the medium into which the wave is to be propagated and the form of energy used to excite the medium into mechanical vibration.

Early experimenters used tuning forks and whistles, and reasonably high frequencies can be obtained by these means. These, however, are capable of only very small power outputs and are not practical sources. Although the low power prohibits certain applications, whistles are being usefully employed for a number of industrial processes such as emulsification and dispersion. Mechanical generators have been used in which a bar or rod is excited into resonance by frictional rubbing, but no application has been found for them. Electrical sparks and discharges and explosive charges will propagate a sound wave in both liquids and gases, but although quite large peak intensities are possible, little control can be exercised over the energy density or the frequency of the generated wave.

Apart from sirens and whistles with certain limited applications, almost all industrial applications are carried out with transducers, energized by an electrical input of the required frequency. The piezoelectric effect in certain natural and synthetic crystals and the magnetostrictive effect exhibited by metals such as nickel are utilized for the generation of ultrasonic waves in liquids and solids. The electromagnetic transducer is employed for exciting liquids and solids, and versions of this type are also used for gas propagation. Large power densities with relatively high conversion efficiency is possible with such transducers.

PIEZOELECTRIC TRANSDUCERS

When certain crystals, having a special type symmetry in their structure, have electrical fields applied to them in certain directions, they distort in shape. Alternatively, if the crystals are mechanically distorted in the same direction an electrical potential is generated. When the

Modern Engineering

by Frank T. Doepel

sign of the stress is reversed, the polarity of the electric charge is reversed and similarly a reversal of an applied potential will cause a change in sign of the mechanical movement. Thus one can see that the crystal transducer can be used to produce or detect ultrasonic waves.

The frequency of any ultrasonic wave can be measured simply by amplifying a piezoelectric transducer's output and feeding it into a frequency meter or scope.

The measurement of ultrasonic energy can also be accomplished by a crystal transducer. When ultrasonic waves are projected against a plain surface, two major influences are experienced. There will be an alternating pressure at the frequency of the propagated wave and a direct pressure due to the radiation. The radiation pressure provides a steady force against a body inserted into the medium and its value is proportional to the mean energy density. This can be expressed mathematically by the following two equations:

$$P_r = a\,E = (F/C)$$

$$\text{And } F = .5\ p\ C\ (WA^2)$$

Where: P_r = Radiation Pressure
a = Proportionality Constant, 0.9-1.0
E = Mean Energy Density
F = Sound Intensity
p = Medium Density
C = Medium Sonic Velocity
W = $2\ \pi$ F where F = Sonic Frequency
A = Maximum amplitude of the sound wave

MAGNETOSTRICTION TRANSDUCERS

For the majority of industrial applications the most widely used transducer is the magnetostriction transducer. Impact grinding employs this principle exclusively. For these reasons, the principles of magnetostriction will be discussed in detail.

When ferromagnetic materials are subjected to a magnetic field, a change in physical dimensions is experienced. Similarly there is a change in the magnetic properties of the material if the dimensions are altered by an external force. These changes are usually designated as magnetostriction effects and take a number of well defined forms.

Magnetostriction can be explained by consideration of the Domain Theory. In most materials the magnetic effects of the orbital electrons nearly neutralize each other. Due to the random orientation of atoms in a solid the magnetic moments of separate atomic groups generally cancel each other out. There are certain exceptions to this situation, and these occur in the materials designated as ferromagnetics. In these materials, an exchange force exists that causes the atomic magnetic fields within a volume of 10^{-8} or 10^{-9} Cm^3 to be parallel, and these domains of magnetic moments can in turn be aligned by an external magnetic field. Each domain is magnetized to saturation, but depending on the crystal structure of the material, the magnetic field may be in any one of a number of fixed directions known as directions of easy magnetization. For example, in a cubic crystal such as that of iron or nickel there are six such directions. (See figure 1.) With an external magnetic field absent, all of the atoms in a single crystal will be oriented to produce a zero resultant field.

In addition, the axes of crystals in polycrystalline materials are oriented in random fashion.

With an increasing external magnetic field, certain of the domains originally magnetized in the direction of the field grow in size, taking over the other differently oriented domains until the complete crystal becomes one large domain. As the field becomes more intense, the domain in each crystal rotates until it is parallel to the field. During this process, the material expands or contracts externally and continues to do so until all the domains are parallel. The material is then said to be saturated.

--Continued on page 22

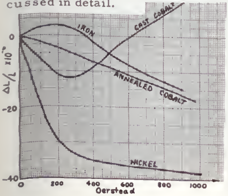

FIGURE 2
(Change in length per unit length as a function of strength for iron, cobalt and nickel.)

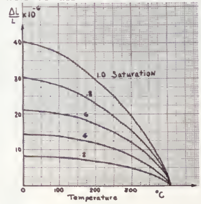

FIGURE 3
(Magnetostriction as a function of temperature for nickel.)

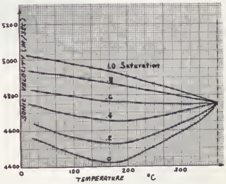

FIGURE 4
(Velocity of sound as a function of temperature for nickel.)

MECH MISS . . .

The Mecheleciv staff presents a streamlined, energy charged co-ed from West Palm Beach, Florida. Patricia Lee Tompkins has blue eyes, sandy hair, and a surprising set of statistics:

Height	161.29 cm
Weight	253 kg
Measurements	0.00053 miles
	60.96 cm
	35,000 mils

Pat transferred to GW from Florida Southern. She was born in Schenectady, New York in 1943, but has lived most of her life under the Florida sun. Pat is now a junior and is majoring in Journalism. She was president of her Phi-Mu pledge class and was co-chairman of the D.C. delegation of Young Citizens at the Democratic Convention. Other interests include dancing, cheerleading, and summer sports like swimming and water skiing. Pat is right on target so look out.

CRITICISM IS NOT FAULTFINDING

by the University Committee of Sigma Tau

The critical period in a young man's life as far as the relation of his education to his career is concerned lies between the ages of sixteen and twenty-one. If he finishes high school and does not go on to a university many roads are barred; for example, only with the greatest of difficulty can he become an engineer, lawyer or doctor. Therefore it appears that the higher education has its privileges. The tendency of management to hire only college men in executive capacities is merely one manifestation of the undefined but very definite recognition on the part of ambitious people "that without a college education you can't get ahead."

But if higher education has privileges, it also gives one the desire and ability to discover, invent and improve; to envision better things and to achieve them. That is the foundation of criticism, which is the builder of civilization.

It was constructive criticism -- intelligent faultfinding -- which brought man out of the caves and jungles of the primitive into the present state of society. It was the desire for something better that gave us improved shelter, food, clothing, transportation, communication, lighting in short, all the comforts of conveniences of life.

Constructive criticism of social and political organization is responsible for man's ideal of freedom, and of the importance of the individual. Without this criticism there is no progress, either of the individual or of society in its larger aspects. More important, inadequate arrangements cannot be bettered by people who have never found anything wrong with them.

Some students, as indiscreet individuals, live essentially within their own depths and never develop a few key relationships which cut below the level of social exchange between themselves and other classmates or faculty members. In order for contact to become a relationship there must be a continuity of exchange, freedom of communication and repetition of meeting.

A fine opportunity for such a relationship was offered each engineering student -- graduate and undergraduate -- at 8:45 p.m., Sept. 23, when Norman Seidle, President, XI Chapter, Sigma Tau Fraternity, chaired the first of seven Open Forums designed to take place on a successive monthly basis. The opening address by Dean Mason was the highlight of the program. Next on the agenda was an open discussion designed to give every member at the meeting a chance to get on his feet and express himself, and to bring out group discussion of pertinent issues.

It is the continuing goal of each of the coming forums to give everyone, faculty and student alike, an opportunity to share their opinions and voice their criticisms in an environment of responsible discussion. "These open discussions," said Dean Mason, "are intended to provide the medium for free, mature exchange of ideas between students, and faculty and students, on matters of interest and concern."

Such a matter of interest may well be the short talk on "Preparing For Graduate Record Examinations" to be delivered by Dean Smith at the forthcoming October 21 Open Forum. This talk, together with a Question and Answer period, will immediately precede the second discussion session which may be entered into by all students and faculty.

Further opportunities to air matters of interest and concern will be given at each of the Sigma Tau sponsored discussion sessions listed below.

CALENDAR OF EVENTS

October 21	A short talk on "Preparing For Graduate Record Examinations" followed by an Open Forum Discussion.
November 18	Panel Discussion on the "Responsibility of the Student."
December 16	A brief talk on "Graduate School Entrance Requirements," followed by an Open Forum discussion.
February 17	A summary on "Preparation of Resumes", preceding an Open Forum discussion.
March 17	Panel Discussion (Topic to be chosen at a later date).
April 21	"Keeping Abreast of Your Field After Graduation" will be discussed prior to the regular Open Forum discussion session.

Tom Thomsen wanted challenging work

He found it at Western Electric

T. R. Thomsen, B.S.M.E., University of Nebraska, '58, came to Western Electric for several reasons. Important to him was the fact that our young engineers play vital roles right from the start, working on exciting engineering projects in communications including: electronic switching, thin film circuitry, microwave systems and optical masers.

The wide variety of Western Electric's challenging assignments appealed to Tom, as did the idea of advanced study through full-time graduate engineering training, numerous management courses and a company-paid Tuition Refund Plan.

Tom knows, too, that we'll need several thousand experienced engineers for supervisory positions within the next few years. And he's getting the solid experience needed to qualify. Right now, Tom is developing new and improved inspection and process control techniques to reduce manufacturing costs of telephone switching equipment. Tom is sure that Western Electric is the right place for him. What about you?

If you set the highest standards for yourself, enjoy a challenge, and have the qualifications we're looking for—we want to talk to you! Opportunities for fast-moving careers exist now for electrical, mechanical and industrial engineers, and also for physical science, liberal arts and business majors. For more detailed information, get your copy of the Western Electric Career Opportunities booklet from your Placement Officer. And be sure to arrange for an interview when the Bell System recruiting team visits your campus.

Western Electric MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

AN EQUAL OPPORTUNITY EMPLOYER

Principal manufacturing locations in 13 cities ☐ Operating centers in many of these same cities plus 36 others throughout the U.S. Engineering Research Center, Princeton, N. J. ☐ Teletype Corp., Skokie, Ill., Little Rock, Ark. ☐ General Headquarters, New York City

A Study of a Preferential Interdendrite

OR

Can a Mechanical Engineer

Some of the greatest advances in our modern technological and scientific knowledge have been based on a seemingly (at the time) trivial observation of an unusual and different occurrence. This paper is the presentation of such a hitherto unobserved trivial phenomenum which someday may lead to an important scientific principle that could have far-reaching effects throughout the entire civilized world. Young engineers should be aware that modern scientific investigation should not be bounded by preconceived limits of practical application. It speaks well for the George Washington University's School of Engineering and Applied Science that the author has been so conditioned by (at least) four years of intensive mental stimulation at that institution that this subtile phenomenum did not escape his keen, inquiring, well-trained, technical, trivial oriented mind.

As any student of metallurgy knows, intuitively, dendritic growth occurs during the transformation of a two, or more, phase mixture from the liquid to the solid state. The condition necessary for dendritic growth is a positive gradient of supercooling. Supercooling occurs when the liquid is cooled below its normal freezing point. A certain amount of supercooling is necessary if the "freezing" is to occur at all and the greater the supercooling the greater the rate of freezing. So with a positive gradient of supercooling, any part of the freezing solid that grows out ahead of the remainder is in a region of greater supercooling and so will have a greater rate of growth. The result is the growth of spikes which form a skeleton like structure out into the liquid. The remaining liquid freezes by increasing the diameter of these original "dendrites."

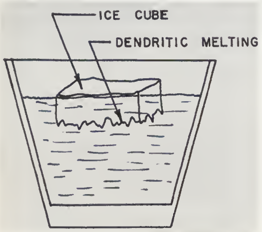

FIGURE 1

This process has been recognized for many years and the physical property changes brought about by this process utilized in the metal industries. Recently, the Spring of 1963 to be precise, a similar phenomenum was noted taking place, seemingly in reverse. One evening while discussing the many faceted wonders of the George Washington University School of Engineering and Applied Science with a fellow student engineer and applied scientist, (actually in his heart he is a frustrated student of pure science but I pride myself on having a tolerant nature), during a lull in a heated debate on the difference or rather lack of difference in the meanings of the terms "Engineering" and "Applied Science" I noticed that the ice floating in a glass of complex polyphase liquid I was holding was exhibiting all the telltale signs of dendritic melting! The bottom of the ice cube had a very jagged appearance, not found on ice cubes melting in water. (See Figure 1.) You can scarcely imagine the feeling of discovery that unsteadied our hands as we prepared fresh solution. It was not unlike the feeling Columbus had when he first spotted those cute little island girls. After mixing two fresh polyphase solutions and noting the same phenomena occurring during the infusion of the solutions, we were convinced that we had stumbled upon something significant. Unfortunately, I must admit that at this first encounter, we were so elated that we completely forgot to maintain a written record (I had stepped on my hand earlier in the evening and was thus unabled to write and my companion having had a traumatic freshman encounter with the English Department refuses to write anything but numbers and formulas using the Greek alphabet). The result was that the next morning we could not quite remember exactly what it was that we had discovered. The only scientific answer was to repeat the experiment under controlled conditions. This was done, and reproducible results, with data, have since been obtained.

Perhaps it would be well if I described the method of preparing the polyphase solution so that any inquisitive engineer or applied scientist can conduct this experiment in the privacy and comfort of his own laboratory and verify our findings. First, a sterile, approximately 4 oz. open, wide mouth beaker is cooled. Approximately 5/8

Transformation in a Complex Polyphase Mixture

be Too Old Fashioned

by Millard E. Carr

of a level teaspoon of $C_{12}H_{22}O_{11}$ (either granulated or powdered) is distributed evenly over the bottom of the beaker. Two milliliters of pure distilled water is gently added to the $C_{12}H_{22}O_{11}$ until all the crystals are transforming into solution. A 1-1/2 inch cube of distilled water at about $30^{o}F$ is then placed in the beaker and approximately 2 oz. of a preprocessed commercial solution of 45 to 50 per cent C_2H_5OH (ethyl alcohol) is added by slowly pouring over the ice (the C_2H_5OH solution we used is sold at local retail chemists under the name of Virginia Gentleman). To assist beginners in preparing the solution, the temperature - composition diagram of the binary system, H_2O - C_2H_5OH, is shown in Figure 2. This system, unfortunately, is not usually covered adequately by most chemical engineering textbooks.

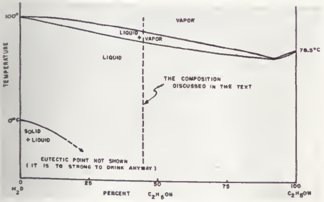

FIGURE 2
An "Old Fashioned" Binary Diagram

Care must be taken during the experiment in order that the solution is not spilled. Aside from the criminal waste of the solution, it was found to be slightly caustic and could result in pain if gotten in an eye or a fresh cut. Certain finishes on furniture may be damaged and while this presents no immediate danger to the experimenter, it was noted that the owner of such furniture (particularly young women) tend to become unreasonably anti-scientific and prone to do bodily harm. Needless to say, such situations are singularly unrewarding and should be avoided by observing necessary safety practices.

An inherent biological danger analogous to radiation was observed and named "fallout" when one of the experimenters, engrossed in the experiment tripped and almost fell out of a seven story window. This experiment should not be attempted rigorously by anyone lacking the necessary experimental, procedural experience. It was observed that certain vapors given off by the multi-phase mixture, when taken internally to relieve the tedium of the experimenters, proved to be mildly toxic. In most cases it brought on hallucinations and definite loss of bodily coordination. (In a more advanced experiment the loss of one of the other experimenter's wife was almost caused by these effects.)

These words of caution should not be taken as a deterrent to the investigation of this highly enlightening experiment by responsible investigators. All that is needed to develop a professional experimental procedure is the desire, and plenty of practice. This experimenter has become quite skillful in the rapid performance of this particular experiment, being able to prepare a beaker of solution with one hand while maintaining the laboratory in a state of stable equilibrium with the other.

I hope this paper has brought to you a fuller understanding of interdendritic phenomena and possibly stimulated further study on your part into similar questions. I myself have rededicated myself to intensive applied scientific study of the strange physiological side effects inherent in this phenomena having recently recovered from a minor liver disturbance. I feel it is our duty to keep the romance of learning alive while we are waiting our six or eight years for our degrees, Good Luck and Keep Schmiling. . . .

NEGATIVE FEEDBACK AMPLIFIERS

by Raymond P. Rocca, Jr.

A FEEDBACK SYSTEM is one in which some function of the output of some part of the system is fed back as a secondary input to the system so as to affect its own value.

In a feedback system it is possible to employ either positive or negative feedback. A POSITIVE feedback system is one in which the phases or polarities of the primary input and the signal fed back are such that they add in the system input mixer and increase the effective gain between the primary input and the output. A NEGATIVE feedback system is one in which the phases or polarities of the primary input and the feedback, which consequently results in a reduction of the effective gain between the primary input and the output.

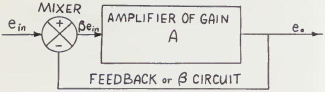

Fig. 1 — Schematic Diagram of Feedback Amplifier

SYSTEM CHARACTERISTICS AFFECTED BY FEEDBACK

The introduction of feedback modifies the characteristics of a system in addition to changing its gain. In general, negative feedback is employed to improve the behavior of a system. For example, with negative feedback it is possible to increase the bandwidth of an amplifier, improve its linearity and consequently decrease the amount of intermodulation and distortion, reduce its output impedance, reduce the output noise which has been introduced within the amplifier, and obtain improved gain stabilization for circuit value changes. The use of positive feedback is usually limited to either oscillators or to special types of feedback amplifiers in which there is a positive feedback system so as to provide an improvement in linearity.

Considerable improvement can be realized in certain system characteristics with a properly designed negative feedback system. The actual characteristics of any system employing feedback are unique to that particular system. Consequently, the application of negative feedback does not ensure an improvement in the characteristics unless certain conditions are satisfied. It is therefore necessary to analyze individually any given system having any amount of polarity or feedback.

Gain and Bandwidth

The gain of a system with feedback is

$$A_f = \frac{A}{1 - A\beta} \qquad (1)$$

where A = system gain with feedback
A = system gain without feedback
β = gain from system output to secondary system input

Note: As the terms A_f, A, and β contain frequency-variant terms, they must be written as functions of $j\omega$ to permit the proper evaluation. The sign of $A\beta$ is positive for positive feedback and negative for negative feedback.

In a negative feedback amplifier in which the absolute value of A times β is much, much greater than 1, the value of A_f is very nearly equal to $1/\beta$ and is relatively independent of the amplifier characteristics. In such a system, the attenuation versus frequency characteristics of the feedback path β should be the inverse of the desired system characteristics.

Distortion

The linearity of an amplifier can be improved appreciably by the application of negative feedback as indicated by

$$D_f = \frac{DA_f}{A} \qquad (2)$$

where D_f = per cent distortion with feedback
D = per cent distortion without feedback

Noise

The amplitude of the noise appearing at the output of a feedback amplifier due to noise introduced at some point in the amplifier is

$$N_o = N_i \frac{A_n}{1 - A\beta} \qquad (3)$$

where N_o = amplitude of noise at output
N_i = amplitude of noise at point it is introduced in amplifier
A = over-all gain without feedback
A_n = gain without feedback between points at which noise is injected and output of amplifier

Note: Since A and β contain frequency-variant terms, they must be written as functions of $j\omega$ to permit the evaluation.

Output Impedance

The output impedance of a system can be changed considerably by the addition of feedback. If negative feedback is employed and if the signal fed back is a portion of the output voltage, the amplifier output impedance will be lower than without feedback. If negative feedback is employed and if the signal fed back is proportional to the output current, the output impedance will be greater than without feedback. The signal fed back in the case of current feedback is a voltage

--Continued on page 22

WHAT'S NEW

Edited by Martin Felker

A DEEP SEA DIVE

An underwater research vehicle designed to dive more than 30,000 feet under the sea will have a hull made of Pyroceram glass-ceramic. Average ocean depth is 12,451 feet, according to the 1964 World Almanac and Book of Facts. The almanac says the deepest reported ocean depth is 37,782 feet. The eight-foot-long, torpedo-shaped vehicle is planned to be the first of a series of similar glass and ceramic unmanned oceanographic capsules probing the depths of the oceans for their secrets. Many oceanographers believe that knowledge of the ocean depths eventually will prove to be more significant than results from space exploration. So far, though, man has been limited to waters relatively close to the surface, even in the new nuclear submarines. The tremendous pressures and bending forces that play upon vessels at great depths have remained unconquered.

Only within the past year or so has serious thought been given to construction of external pressure vessels with solid glass or ceramic walls instead of walls made of metals or composite materials such as glass fiber-epoxy and glass-metal.

Pyroceram glass-ceramic was chosen as the hull material primarily because of its compressive strength, which is higher than 300,000 pounds per square inch. The material characteristically doesn't fail under compression, thus gets stronger the deeper it goes. The theoretical strength to weight ratio of the glass-ceramic is higher than that of high strength aluminum and steel alloys now used for underwater vehicles.

CREATING A STORM IN THE LABORATORY

Artificial rainfall and the resulting runoff that can be measured in the laboratory will soon be a part of hydraulic engineering research at the University of Illinois.

The rainfall simulator will be constructed of thousands of hypodermic needle points mounted on a steel frame of adjustable height. The needle points will be connected in groups to a number of electronically operated direct displacement pumps. The pumps will force water through the needle openings to produce fine drops of artificial rainfall. The instrumentation will be designed to create storms of variable rainfall intensities and variable movement speeds. Artificial storms will be produced that can move across a model watershed in upstream, downstream, or other desired directions. The electronically measured runoff from the model watershed will be recorded on punched cards or tapes for computer analysis. The objective of the research is to investigate the basic laws of the flow of water on drainage basins by means of controlled experiments.

MULTI FREQUENCY TRANSISTORIZED FISH CALL

Now you can call the fish to your exact fishing spot with an electronic transistorized Fish Call. Ichthyologists have known for some time

that fish respond to sonic oscillations between 50 and 300 cycles, and to light waves.

The dial allows selection of five different variants of sound waves. In addition to the sound selection, the unit is also capable of producing light waves for maximum attraction of all species of fish. The sound waves, though only moderately audible to the human ear, travel some 200-300 yards through the water and attract the fish directly to the source. From then on it is up to the skill of the fisherman to get the fish to bite.

CAMPUS NEWS

ASCE

Start off your academic year right, join the American Society of Civil Engineers and take the first step toward preparation for entry into the engineering profession.

Student Chapters of the ASCE are established to help you enrich your college courses by beginning those professional contacts and associations which, continued through life, are so valuable to the practicing engineer. DON'T DELAY. Join now and take that first step.

As a member your attendance is requested at our monthly meetings held on the 1st Wednesday of the month. The meeting consists of a short business session followed by either a speaker from the engineering profession or a movie of interest to all. The main purpose of our meetings is to give you the member an opportunity to learn of the engineering profession.

Field trips are another aspect of ASCE activities. We visit such places as Goddard Space Flight Center, David Taylor Model Basin, and the Bethlehem Steel Plant near Baltimore.

ASCE has a summer job placement service for its members. We have many contacts with local engineering firms and each spring find summer jobs for many of our members.

We hope to see you at our first meeting.

ASME

The student branch of the American Society of Mechanical Engineers will hold its first meeting on October 7 at 8:30 in room 304 of Tompkins Hall. All engineering students are invited. Check ASME's bulletin board for further details.

THETA TAU

Gamma Beta Chapter of Theta Tau, in an effort to be of increasing service to the University and its students, joined with Sigma Tau in proctoring and grading the placements tests given incoming freshmen and took part in the "Old Men" program during orientation.

We are looking forward to the celebration, with our alumni, of the 60th anniversary of the founding of Theta Tau on October 15.

We welcome the future engineers who are with us for the first time this semester and wish them success with their work at GW.

IEEE

The Officers of IEEE for the 1964-65 School Term are:

Tom Dillon . . . . .Chairman
John Starke . . . . Acting Vice-Chairman
Joe Proctor. . . . . Treasurer
Rudy Decatur . . . . Secretary
Judy Popowsky . . . . Engineers' Council Representative
Mr. George Abraham . . . . Counselor

For its first regular meeting, The George Washington University Student Branch of IEEE (Institute of Electrical and Electronics Engineers) is honored to have as its guest speaker Dr. William W. Eaton. Dr. Eaton will be speaking on "Engineering Management" -- a topic of interest to all engineers.

This first regular GW Student Branch meeting of IEEE will be held on the first Wednesday of the month, October 7, 1964 in Room 200, Tompkins Hall. The business meeting will start at 8:15 P.M. There will be an opportunity at this meeting for new students to become members and to pay their dues.

Dr. Eaton's presentation will be preceded by a short, but very important, business meeting. As usual refreshments will be served following the meeting.

First, what is the obvious? It's obvious that you're in demand. You don't have to worry about getting your material wants satisfied. And you don't have to worry about getting opportunities for professional growth.

But, if you look beyond the obvious, you'll realize now that you're going to want something more than material rewards from your career. You're going to want **pride**—pride in your personal, individual contribution.

Melpar is a proud Company. We're proud of our approach to the solution of problems; we're proud of our growth pattern; and we're proud of the communities that surround our laboratories and plants in Northern Virginia.

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Look beyond the obvious . . .

Melpar's broad activities have created requirements for engineers and scientists with degrees in Electrical Engineering, Mechanical Engineering, Physics, Chemistry, Mathematics, and the Biological Sciences.

If you want an opportunity to be proud of your contribution and your Company, we're interested in hearing from you. Tell us about yourself. Either ask your Placement Director for more information, or write to our Professional Employment Supervisor. Tell him if you would like to hear from one of your college's graduates who is now progressing at Melpar.

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NEGATIVE FEEDBACK AMPLIFIERS—Con't.

which is developed across a resistor in series with the load.

The output impedance of a system employing current and/or voltage feedback can be determined.

For voltage feedback only

$$Z_f = \frac{Z}{1 - K_1\beta_1} \qquad (4)$$

For current feedback only

$$Z_f = Z = K\beta_2 R_f \qquad (5)$$

where Z = output impedance of amplifier without feedback.

Z_f = output impedance of amplifier with feedback.

K = gain of unloaded amplifier without feedback. If loaded amplifier gain A without feedback is known, value of K can be determined from relationship $K = A + AZ/R_L$ where R_L = value of load resistance.

β_1 = ratio of voltage fed back to secondary input of amplifier to output voltage.

β_2 = ratio of voltage fed back to secondary input of amplifier to voltage developed across the resistor R_f in series with the load for providing current feedback.

Note: The signs of $K\beta_1$ and $K\beta_2$ are positive for positive feedback and negative for negative feedback.

In order to realize the advantages of negative feedback, the amplifier and its feedback must be so arranged that oscillations do not occur. In the normal range of frequencies this presents no problem, because here the circuit arrangements are such that the feedback is negative. However, at both very low and very high freqüencies, the amplifier stages produce phase shifts that cause the phase of the feedback factor $A\beta$ to differ from the phase corresponding to negative feedback. This introduces the possibility of $A\beta$ reversing its polarity and thereby introducing positive feedback that directly assists in the production of oscillations. To be unconditionally stable, i.e., free of oscillations under all conditions, it is necessary that the circuit arrangements be such that the feedback factor $A\beta$ have a magnitude less than unity under conditions where the phase shift of the feedback factor $A\beta$ differs by 180° from the negative value applying to the midfrequency range.

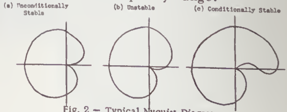

Fig. 2 — Typical Nyquist Diagrams

The situation existing with respect to oscillations in a feedback amplifier is often shown by plotting a curve, called a Nyquist diagram, showing on the complex plane the variation in the transmission A around the feedback loop as the frequency is varied from zero to infinity. Typical diagrams of this type are shown above. At (a) the amplifier is unconditionally stable because when the phase angle of A is zero (positive feedback), the magnitude of A is less than unity. The diagram at (b) is the same as (a) except that the amplification has been increased until $|A\beta| > 1$ when the phase angle is zero; in this case oscillations occur. The case shown by the solid curve in (c) represents conditional stability. Here oscillations do not occur because the curve does not enclose the point 1,0; however, if the gain A is now reduced so that conditions correspond to the dotted line, then oscillations will start, because the point 1,0 is now enclosed by the $A\beta$ curve.

The phase-shift and amplification characteristics of the individual stages of the amplifier are, therefore, of particular importance in connection with feedback systems since they affect the feedback factor through their relation to A. It is characteristic of all amplifier stages that the falling off in amplification at both low and high frequencies is accompanied by a phase shift with respect to the phase relation existing in the middle range of frequencies where the amplification is substantially constant with frequency.

ULTRASONICS—Continued

It should be stated that the changes in dimensions are very small. Nickel shows one of the largest changes per unit length, but this actually amounts to only about 30 parts per million or 0.00036 inch in 12 inches. If the material is at mechanical resonance, the change may be as high as one part per thousand, but will be limited by the fatigue properties of the material. The static force will be determined by the change in length and modulus of elasticity of the metal. (See figure 2, page 6.)

All magnetostrictive materials are temperature sensitive, the material losing its magnetism as the temperature rises until the Curie point is reached, where all magnetic properties cease. The graph (figure 3) on page 7 shows the temperature effect plotted against the magnetostriction factor for nickel.

From the preceding graph, it can be seen that temperature has an important effect on the magnetostriction effect.

Figure 4 (page 7) shows the variation in sonic velocity with temperature for nickel.

As the resonant frequency is dependent on the velocity of sound through the material this variation with temperature must be considered when transducers are designed.

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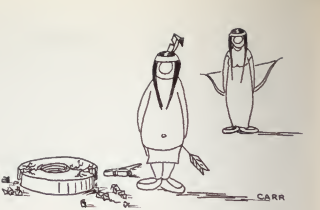
THE SHAFT



Girls . . . beware the Engineer

Verily I say unto you, beware of the engineer; for the engineer is a strange being possessed by many devices; yea, he speaketh in parables which he calleth formulae, and he wieldeth a big stick which he calleth a slide rule; he hath but one Bible—a handbook.

Always he carrieth books with him, and he entertaineth his maiden with steam tables. Verily though the damsel expecteth chocolates, when he calleth, he opens the package to reveal samples of a new alloy.

Yea, he holdeth a damsel's hand, but only to measure the friction, and he kisseth only to test viscosity. For in his eye shineth a faraway look which is neither love nor longing, but a vain attempt to remember an equation.

Even as a little boy, he pulleth a girl's hair, but to test its elasticity, and as a man he discovereth different devices, for he would hold a maiden to his bosom only to count the palpitations of her heart, and to reckon the strength of her materials..

Alas! his affairs are a series of simultaneous equations, involving two unknowns and yielding periodic functions.

* * *

"I have an uncle that is a magician. Every time he walks down the street he turns into a bar."

* * *

A patient at a mental hospital who had been certified cured was saying good-by to the head psychiatrist.

"And what are you going to do when you get out in the world?"

"Well I may go back to Wisconsin and finish my Ap S 83 course. Then, I liked the Army before, so I may enlist again. He paused a moment and thought. "Then again, I may be a teakettle."

Many a tight nut has been loosened by a small wench.

* * *

Girl answering telephone in Strong Hall: "Sorry, Betty is not here. This is her 114-pound five-foot-three, blonde, blue-eyed roommate."

* * *

At a recent convention of the American Institute for the Preservation of Wooden Toilet Seats it was decided that the organization's name was too long. Consequently they named it the Birch john Society.

* * *

Coed: "You remind me of Nero."

Engineer and Applied Scientist: "Why?"

Coed: "Here I am burning and you're just fiddling around."

* * *

An elderly man approached a small boy and asked: "Tell me young man, do you have a fairy godfather?"

"No," replied the little boy, "but I have an uncle we're all a little suspicious of."

* * *

If young girls stay out late, drink, smoke and pet, men will call them fast--as fast as they can get to a phone.

* * *

Recently, a publishing house released a book entitled: Newly translated From French--27 Mating Positions. The book immediately began to sell so fast that the presses were working overtime to satisfy the terrific demand for them. "This is most extraordinary," said the publisher. "I've never seen such a demand for chess books."

* * *

In golf, it's distance; in a cigarette, it's taste; in a volkswaggen, it's impossible.

* * *

"I've got the most beautiful wife in the world . . . the trouble is her husband wants her back."

How many magazines does it take to fill a baby carriage? One Mademoiselle, One Country Gentlemen, A Look, A Few Liberties . . . and a Little Time.

* * *

A husband and wife were to go to a costume party. The husband decided to go dressed as a bull and the wife as a cow. While traveling to the party their car ran out of gas. Glancing out the window the husband spied a gas station across a large field. The wife didn't want to be left alone, so they both proceeded across the field, the couple heard a snorting and pawing of the ground. A huge bull was beginning to charge them. The petrified wife screamed, "What are we going to do?" The husband replied, "I'm going to eat grass, you better brace yourself."

* * *

She was a gorgeous girl
And he was a loving male
He praised her shape in English
French, Italian, and Braille.

* * *

I used to go out with a perfect 36, till my wife came home with a loaded 45.

* * *

Ivan Papalosky liked to know all about his employees who toiled in his business. One day he came upon a new young man who was dexterously counting out a wad of the firm's cash.

"Where did you get your financial training, young man?" he asked.

"Yale," answered the young man.

"Fine," he said. "And what's your name?"

"Yackson."


IBM

Advancement in a Big Company: How it Works

An Interview with General Electric's C. K. Rieger, Vice President and Group Executive, Electric Utility Group

C. K. Rieger

■ Charles K. Rieger joined General Electric's Technical Marketing Program after earning a BSEE at the University of Missouri in 1936. Following sales engineering assignments in motor, defense and home laundry operations, he became manager of the Heating Device and Fan Division in 1947. Other Consumer-industry management positions followed. In 1953 he was elected a vice president, one of the youngest men ever named a Company officer. Mr. Rieger became Vice President, Marketing Services in 1959 and was appointed to his present position in 1961. He is responsible for all the operations of some six divisions composed of 23 product operations oriented primarily toward the Electric Utility market.

Q. **How can I be sure of getting the recognition I feel I'm capable of earning in a big company like G.E.?**

A. We learned long ago we couldn't afford to let capable people get lost. That was one of the reasons why G.E. was decentralized into more than a hundred autonomous operating departments. These operations develop, engineer, manufacture and market products much as if they were independent companies. Since each department is responsible for its own success, each man's share of authority and responsibility is pinpointed. Believe me, outstanding performance is recognized, and rewarded.

Q. **Can you tell me what the "promotional ladder" is at General Electric?**

A. We regard each man individually. Whether you join us on a training program or are placed in a specific position opening, you'll first have to prove your ability to handle a job. Once you've done that, you'll be given more responsibility, more difficult projects—work that's important to the success of your organization and your personal development. Your ability will create a "promotional ladder" of your own.

Q. **Will my development be confined to whatever department I start in?**

A. Not at all! Here's where "big company" scope works to broaden your career outlook. Industry, and General Electric particularly, is constantly changing — adapting to market the fruits of research, reorganizing to maintain proper alignment with our customers, creating new operations to handle large projects. All this represents opportunity beyond the limits of any single department.

Q. **Yes, but just how often do these opportunities arise?**

A. To give you some idea, 25 percent of G-E's gross sales last year came from products that were unknown only five or ten years ago. These new products range from electric tooth brushes and silicone rubber compounds to atomic reactors and interplanetary space probes. This changing Company needs men with ambition and energy and talent who aren't afraid of a big job—who welcome the challenge of helping to start new businesses like these. Demonstrate your ability—whether to handle complex technical problems or to manage people, and you won't have long to wait for opportunities to fit your needs.

Q. **How does General Electric help me prepare myself for advancement opportunity?**

A. Programs in Engineering, Manufacturing or Technical Marketing give you valuable on-the-job training. We have Company-conducted courses to improve your professional ability no matter where you begin. Under Tuition Refund or Advanced Degree Programs you can continue your formal education. Throughout your career with General Electric you'll receive frequent appraisals to help your self-development. Your advancement will be largely up to you.

FOR MORE INFORMATION on careers for engineers and scientists at General Electric, write Personalized Career Planning, General Electric, Section 699-11, Schenectady, N. Y. 12305

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